Environmental Aspects of Integrated Steel Plants

A Report Respectfully Submitted
to
The Province of British Columbia

by
The British Columbia Steel Mill
Environmental Survey Team

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Hon. Elwood N. Veitch, Minister of Regional Development
Hon. Bruce W. Strachan, Minister of Environment

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EXECUTIVE SUMMARY

This examination of the potential environmental impacts of an integrated steel mill in British Columbia was initiated as a result of a visit by personnel from the China Steel Corporation (C.S.C.) of Taiwan to the Government of British Columbia. C.S.C. advised that they were planning an expansion of their steel-making capacity in the amount of 3,000,000 tonnes per year and were considering alternatives to expanding in Taiwan, one area being British Columbia.

The possibility of such a development was of interest to the government; however, it was concluded that before proceeding further, a preliminary overview should be made of the environmental aspects of such a project. In order to assist the provincial Cabinet in making this assessment, the British Columbia Steel Mill Environmental Survey Team was appointed by the Honourable Elwood Veitch, Minister of Regional Development and the Honourable Bruce Strachan, Minister of Environment. The Survey Team included experienced researchers, operators and environmental personnel. Visits to steel-making operations in Asia and Canada were then arranged. The Survey Team visited five modern integrated steel mills - two in Korea and one each in Taiwan, Japan and Canada. Discussions were held with key personnel in the plants that were visited, government environmental bodies in the host countries, university specialists concerned with industrial environmental issues and industry organizations. Extensive written material was supplied by the parties visited, supporting in detail the subjects discussed. The Ministers accompanied the team in Korea and Japan.

The mandate of the Survey Team was to review the environmental aspects of modern fully integrated steel mills; as well as the standards under which they are operated. The Survey Team was to assess whether an integrated steel plant, sited in British Columbia, could operate within acceptable environmental specifications. If so, a recommendation was to be made concerning the desirability of proceeding with pre-feasibility studies of this project.

In the last 15 years, the technology and equipment necessary to maintain much improved environmental standards have become commercially available. During this period, the percentage of capital costs required to reach these more stringent environmental standards has escalated from less than 8% to, in some cases, in excess of 20% of the total plant investment. On the basis of the successes achieved by these developments and the observations and information obtained both in Asia

and from Canadian sources, the conclusion was reached that available air and water emission control technology and modern solid waste management practices justify proceeding with pre-feasibility studies of the establishment of an integrated iron and steel production facility in British Columbia. The ultimate environmental feasibility of the plant will be contingent on establishing rigorous criteria and standards for air and water quality, exacting control in analysis and sampling, and programs of marine and land monitoring including initial base line studies. It is imperative that the assimilative capacity of any potential site be based on the combined (and cumulative) effects of population and industrial activity. Such capacity must include the long term viability of marine and terrestrial ecosystems in the region.

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1.0 BACKGROUND

During a visit by personnel from the China Steel Corporation (C.S.C.) of Taiwan to the Government of British Columbia, it was revealed that C.S.C. was planning a 3,000,000 tonne per year increase to its steel production capacity, which currently stands at 6,000,000 tonnes per year. Among the alternative areas being considered were sites in British Columbia. The proposed operation would require an investment by the company of $4 billion, and would create several thousand direct and indirect jobs in British Columbia.

While this project was of interest to the government, it was considered essential that a preliminary overview of the environmental aspects of such a development should be made as the first step. In order to assist the provincial government in making the assessment, the British Columbia Steel Mill Environmental Survey Team was appointed by the Honourable Elwood Veitch, Minister of Regional Development, and the Honourable Bruce Strachan, Minister of Environment. The Survey Team included personnel with experience in related operations, metallurgical research, and environmental projects. Visits to modern integrated steel plants in Asia and Canada, including the plants most recently commissioned in those areas, were arranged. The Ministers accompanied the Survey Team in Korea and Japan.

On each visit, efforts were made to consult with the environmental control staff, and by means of plant tours and documentation, to obtain information on problems and solutions affecting air and water quality. Notably, four of the mills were located on salt water. Disposal of solid waste was also investigated.

The Survey Team visited a total of five fully integrated modern iron and steel facilities, two in Korea, and one each in Taiwan, Japan and Canada. In each of the Asian countries, meetings were arranged with the federal ministries of the Environment. In Japan, a meeting included representatives for environmental control from the top five steel producers. In Taiwan, the local environmental administration of the city where the mill was located was consulted. A listing of these non-industry visits is included in section 5.0.

The combination of visits to both industry and government agencies was particularly helpful in gaining an understanding of the overall process of feedback between regulation, compliance and improved performance (or control) in the new cultural settings.

Interesting approaches to environmental regulation were encountered. In Japan, for example, local community/industry agreements are widespread. They contain "consensus" or personal obligation goals. That is to say, the pollutant levels are not enforceable at the local level by law, only by an "honour" system. National standard violations do carry stiff penalties. Notably, in all the Asian countries, more stringent objectives were continually being set for both air and water quality.

In the Canadian greenfield project, located on Lake Erie, early and direct involvement of local community representatives was also an important feature. The Nanticoke Environmental Management Committee (NEMC) formed in 1978 included government, industry and public participation. This process is described in Appendix I.

2.0 OBJECTIVES

The objectives of the Survey Team can be summarized as follows:

1. Examine and report on the environmental aspects of production facilities of the modern integrated steel mills visited.

2. Set out and comment on the environmental requirements applicable to steel mills in the countries visited and elsewhere as available.

3. Report on the practice and technology used to keep plants within established environmental standards.

4. Report on the environmental impact observed and its possible acceptability in British Columbia.

3.0 SURVEY TEAM MEMBERSHIP

The British Columbia Steel Mill Environmental Survey Team consisted of four members.

Dr. J. K. Brimacombe (Team Leader)	University of British Columbia
Dr. G. W. Poling	University of British Columbia
S. M. Rothman	Retired Professional Engineer
Dr. P. R. West	University of Victoria

The Survey Team was supported by three government environmental experts.

Earle Anthony	Environment Canada
Dr. Leo Buffa	Environment Canada
Dr. Richard Wilson	British Columbia Ministry of Environment

4.0 PLANTS TOURED AND BASIC STEEL-MAKING PROCESSES

Four Asian plants were visited: the Pohang and Kwangyang plants of the Pohang Iron and Steel Company in Korea, the Keihin plant of NKK Limited in Japan, the China Steel plant at Kaohsiung in Taiwan and the Stelco Lake Erie plant in Canada, all of modern design. Based on economies of scale, the capacity of a single line plant is usually in the order of 2.5 to 3.0 million tonnes. Of the plants visited, the Japanese, the Taiwanese and one of the Korean plants each have capacities of about 6,000,000 tonnes and the second Korean plant has a capacity of approximately 9,000,000 tonnes. The Canadian plant is located on a new greenfield site with space enough for production in excess of 10,000,000 tonnes. Production from present facilities at this plant is in the order of 1,500,000 tonnes per year. The core production facilities which were the main point of interest to the Survey Team are essentially the same in each of the above plants consisting, as shown in Figure 1, of sinter plants for agglomerating fine ore, coke ovens to produce metallurgical coke from coal, blast furnaces

for iron production, oxygen steel furnaces for producing steel and continuous casting machines for converting liquid steel in various cross sections to meet rolling mill market requirements.

The Asian plants depend entirely on imported ore and coking coal, which determines their location on tide water and also mandates the need for large storage areas (up to three months requirements). Winter conditions, which prevent year-round water access, make five months storage a necessity at the Canadian plant.

The basic plant design evolved during the 1950s with the development of feed preparation for the blast furnace, oxygen steel making and continuous casting. It was these developments that permitted increasingly larger units which in turn make it possible to rationalize the collection, control, and reuse of the intermediate waste gas and solid materials, the major cause of air and water pollution in older steel plants.

The major potential pollutants from the producing units are the dusts and fume (particulate) gathered in either dry or wet collectors, which are returned to the process via the sinter plant charge. The coke plant offgas contains tars and other hydrocarbons which are condensed and further processed in an associated chemical plant. The blast furnace, oxygen steel furnace and coke oven gases have some heating value. After particulate removal, these gases are used wherever required for process heat, with the surplus diverted to power generation. (Up to 95% of plant power requirements can be generated from these sources.) From observations both within the operating plants and externally in the overall plant site, control of dusts appeared to be effective. For example, no visible plumes extending off-site were observed at any of the locations.

In addition to the dusts carried in the gas stream, the gas also carries a certain portion of the sulphur contained in the iron ore and coal. At four of the plants, raw material purchases had strict sulphur limits so that even without treatment the final waste gases were able to meet national and local environmental standards for SO_x (SO_2). At one plant, owing to higher environmental standards, both sinter and coke oven gases were treated for removal of SO_x by conversion to ammonium sulfate or sulphuric acid.

In the sintering, coke oven and power generation operations, conditions are such that oxides of nitrogen (NO_x) are produced and are present in the off gases from these operations. In Japan, a process has been developed to remove NO_x from the sinter plant waste gas and is in

place at the Keihin operation. Research work is ongoing to develop a process to treat coke oven gas.

Dusts and particulates are potential air pollutants from various points in a steel facility, and all plants visited had both advanced equipment and vigorous control processes to control these emissions. Control equipment included wet scrubbers, electrostatic precipitators and bag houses; at one plant, more than 100 bag houses had been installed, largely to control "fugitive" emissions in such operations as furnace tapping, furnace charging or materials handling transfer points.

As noted, large stockpiles of coal and iron ore are maintained at the Asian plants visited and all have extensive equipment for stockpiling and reclaiming these feed stocks. Potential dusts from these stockpiles are largely controlled by a combination of specially designed water sprays, surface sealants and enclosed conveyor systems. The general appearance of the yards and the stockpiles indicated that the dust suppression practices at the sites visited were effective. Heavy rains can carry some stockpile material into the drainage system, and some of this material may be discharged to the surrounding sea water. However, the Japanese plant could collect and treat up to 100 mm of rain per day. The Canadian plant had complete perimeter collection and lagooning of run-off water from the stockpiles.

As reported above, at all plants visited, dusts and fume from the blast and steel furnaces are separated from the gas stream by a wet system. The slurry from this system is collected with smaller slurry streams gathered from other systems and processed for separation of the solids. The solids reclaimed are recycled to the sinter plant and the water reclaimed is recycled with the process water. Up to 95% of the process water is recycled.

Liquid wastes from the coke plant gas stream require a much more complex treatment than the solid/liquid separation suitable for the dust and fume slurry recovered from the blast furnace and oxygen steel furnaces. This process is described in a later section on water quality.

Excluding slags, the total amount of wastes including sludges, trash and untreatable waste liquids which cannot be recycled or recovered in some marketable form is relatively small. Solid waste disposal at two of the plants was by a rotary kiln. Slag or ash produced was recycled to the sinter plant or stored in a designated area impervious to leaching. The quantity of such wastes was such that long term disposal was not considered to be a problem.

Large volumes of water are required for cooling process equipment in the plants. In several of the plants, the water is used successively for different cooling and dust abatement purposes in a recirculating system such that only 5% of makeup water is required.

The major waste by-product from the steel plants is the slag from the blast and steel furnaces. These slags are a mix of lime, silica and alumina with some 2% residuals including sulphur and oxides of iron and manganese. Heavy metals and elements such as lead cadmium, arsenic, chromium and mercury were reported as not detectable in Japan or well below any established limits in Taiwan.

Where markets are available, granulated slag from the blast furnace is used in the production of cement, while lump slag is used for road ballast. In Japan the bulk of the slag was disposed of in this way; in Korea surplus slags are used for expanding the plant site by dumping in a marine landfill; and in Taiwan surplus slags were either dumped in the ocean or used as controlled ocean fill to expand the plant site.

Initial studies in Taiwan after a year of ocean dumping indicated no difference between the fish or water in the dumping area as compared to areas not affected by dumping. Some differences were reported in the macrobenthos. Further studies are under way to determine whether longer exposure will create environmental problems affecting the fishery.

All the plants were essentially operated from control centres where the majority of operating personnel were located. Operating units were controlled by preset programs, where considered appropriate, with remote measurement of process data. In two of the plants, measuring stations to monitor constantly emissions subject to environmental standards were located in a well designed pattern with data relayed to the control centre. Remote T.V. monitors covering critical operations were also available to the operators. In one plant the data were reported on-line to local authorities. These central systems were indicative of the extent to which the latest technology has been applied in these modern steel mills.

A notable feature of the Asian facilities was the extent to which a wide variety of vegetation was incorporated throughout the plant grounds and beyond. Trees, shrubs and flowers lined roadways, boulevards and walkways with numerous concentrations throughout the mill site. At one location, where the workers' quarters are associated with the mill, an outstanding

community has been established with the whole townsite beautifully landscaped. Landscaping also was a feature at the other plants.

Management in all cases made a point of emphasizing these developments. This demonstrated several points: firstly, that sensitive vegetation could co-habit with the environment of a modern steel plant; secondly, that senior management acknowledge the public concern for environmental conditions and were prepared to demonstrate in a public way that they were paying attention to these concerns; thirdly, that beautification added to the working environment.

5.0 ENVIRONMENTAL AUTHORITIES INTERVIEWED

The following agencies met with the Survey Team to discuss standards for air and water quality, and the regulation of solid waste with particular reference to iron and steel making operations:

Korea:

a) Environment Administration, Republic of Korea
(Representative of Environmental Management Corp. of Korea present)

b) Korea Environmental Preservation Association

c) Institute for Environmental Research Yonsei, University, Seoul

Japan:

a) Managers of Environmental Control Department of the Japan Iron and Steel Federation
(Environmental Control Managers of five major steel companies present).

b) Japanese Environmental Agency
Directors of Air Quality Bureau, Air Pollution
Control Division and Office of Marine Pollution and Waste Management

c) Ministry of International Trade and Industry
Director and Deputy Director of Environmental Protection Division

Taiwan:

a) Environmental Protection Administration,
Presentations of Directors of Bureau of Water Quality Protection, Bureau of Performance Evaluation and Dispute Settlement, and Bureau of Air Quality.

b) Environmental Protection Administration, City of Kaohsiung (location of China Steel Corporation Works).

6.0 EXISTING ENVIRONMENTAL STANDARDS

British Columbia implements, through the Ministry of Environment, site-specific regulations with respect to emissions to air, effluents to water and solid waste disposal on land . Guidelines to "anticipated ranges" are provided in the publication Pollution Control Objectives for the Mining, Milling and Smelting Industries of British Columbia (1979). Excerpts of these objectives plus those from Korean, Japanese, Taiwanese and Ontario regulatory bodies are included in Appendix II. Comparison of regulations will indicate that all jurisdictions have similar maximum permissible levels for emissions to air. The three Asian jurisdictions were somewhat more lenient with respect to several parameters in effluents to fresh or marine waters. Regulations are changing and gradually becoming more stringent. In addition, there are new concerns such as dioxins, PCBs (polychlorinated biphenyls), PAHs (polycyclic aromatic hydrocarbons) and other organic compounds. British Columbia and Canada are currently considering new maximum limits for these and other elements or compounds of special concern.

7.0 POTENTIAL IMPACT ON WATER QUALITY

7.1 Pollutants

The production of coke from coal, molten iron from ore, steel from iron and finished products from steel generate process and cooling wastewaters which are similar among different iron and steel plants using similar processes.

The list of pollutants and parameters that are considered for control by various environmental agencies around the world is long and complex and it includes conventional parameters such as pH, ammonia, suspended solids, oil and grease, cyanide, phenolics, heavy metals and numerous organic compounds such as PAHs, benzene and solvents which may be considered toxic and persistent once discharged into the environment.

7.2 Effluent Treatment and Quality

Generally speaking all mills are concerned with the containment and treatment of storm water runoff, process and cooling water, and all practice a high degree of recycling. The differences among mills are basically the extent of treatment applied, number and type of parameters regulated, monitored and reported and the monitoring of environmental parameters. The findings are summarized below.

a) **Storm runoff.** In general all plants visited make an effort to contain runoff from raw material stock piles. Treatment, when existent, consisted of settling of solids before discharging to receiving waters. At times, stockpiling areas were paved with asphalt or concrete, or covered with grass to minimize infiltration through the ground.

   At the Canadian mill, where the Survey Team was able to observe in greater detail the system for collecting and disposing of runoff water, clean runoff is collected in ponds and then discharged to receiving waters in a controlled manner. Runoff from raw materials stockpiles is collected and re-used on the same piles for dust suppression. Runoff from other process areas is also collected and re-used.

Comment: It is clear that, in spite of the magnitude of the areas used for stockpiling raw materials, the water runoff, once collected and contained in a holding pond, can either be reused or treated to a satisfactory level before discharging it into receiving waters.

b) **Coke oven wastewater.** All five mills reuse their coke oven wastewater after a biological treatment followed by some form of filtration. A 10 to 15% bleed-off is allowed in order to control the buildup of undesirable chemicals and prevent scaling.

All of the mills emphasized their efforts in reducing chemical oxygen demand (COD) and indicated their compliance with strict effluent standards. These standards apply to the final effluent discharged by the mills to the receiving waters.

One mill provided actual data on coke oven effluent after treatment (pH 7.7; COD 83.0; CN 0.84 mg/l; phenol 0.12 mg/l; oil and grease 1.0 mg/l; TSS 22.0 mg/l). Ammonia and persistent organics were not monitored.

Another mill indicated that COD removal efficiency achievable with tertiary treatment is 99.0% At the meeting with the Japanese Iron and Steel Federation it was stated that, today, the treatment of coke oven wastewater with activated charcoal is a commercially applied technology. The statement is significant as it points out that, when in doubt on the ability of a given treatment facility to remove persistent organics, a combination of primary, biological and tertiary treatment could be demanded.

At the Canadian mill, coke oven wastewater goes through a biological system and ammonia stripper before recycling. A 10 to 15% bleed-off is sent to a central system where all blowdowns from various process areas are treated before discharge.

Comment: Coke oven effluent can be treated by removing organics with biological methods, inorganics with physical/chemical methods and activated carbon filtration can be added to improve the quality of the final effluent. The information collected at the Canadian mill confirms this point. The application of these technologies to a coke oven effluent prior to mixing with other mill effluent should be regarded as a requirement if there is any doubt on the final quality of the effluent.

c) **Other process and cooling water.** All mills stressed water recycle after preliminary treatment and cooling if necessary. They also indicated further treatment before final discharge.

d) **Final effluent quality.** Data were provided on the quality of the final combined effluent before discharge to receiving waters. In Asia the best data set was provided by C.S.C. with a comparison with standards applicable in Taiwan, Japan and Germany. The comparison is shown in Appendix III.

At the Canadian mill a detailed discussion took place on the treatment and testing of the final effluent before discharge. As indicated above, all waters receive preliminary treatment at the point of use before being recycled. All blowdowns from the various process areas are sent to a central treatment plant consisting of solids separation, chemical treatment of ammonia, cyanide, phenols etc., filtration, pH adjustment and dechlorination. A pond with five days retention time provides equalization and temperature control before final discharge.

The quality of the final effluent is monitored in accordance with strict requirements by the Ontario Ministry of Environment. The number and type of parameters analyzed and reported by the Canadian mill is far more comprehensive than that observed at the Asia mills.

With regard to organic chemicals of concern, such as non-halogenated volatiles (e.g. Benzene), base neutral extractables (e.g. polycyclic aromatic hydrocarbons) and halogenated volatiles (e.g. tetrachloroethylene) they were mostly non-detectable (less than 1.0 PPB) or very low. Chlorinated dibenzodioxins, dibenzofurans and polychlorinated biphenyls were not detected.

Canadian data and discussion with personnel at the Canadian mill suggest that compliance with stricter and more comprehensive requirements can also be achieved.

e) **Biomonitoring of final effluent.** During the visits to the Asian mills the data available on the quality of the final effluent were only those required by regulation. No biomonitoring of the effluent was carried out at any of the mills.

At the Canadian mill, a battery of tests was carried out to check lethal and chronic toxicity of the final effluent. Static and continuous flow through bioassay tests were carried out on rainbow trout as well as indigenous aquatic test organisms. Avoidance, hatchability and reproduction tests were also carried out. The mill personnel stated that no significant difference was found between the tests with 100% effluent and the controls conducted with lake water. The company has a stated objective of 100% survival in pure effluent with the plant operating normally.

Detailed results were not made available to the team as the company regarded them as confidential. Members of the Survey Team were able to observe fish from the lake swimming through the effluent.

Comment: When wastewater from an integrated steel mill is managed as seen at the Canadian mill, it is reasonable to expect that the impact on the receiving environment could be minimal.

f) **Back-up or safety.** Considerable measures have been taken at the Canadian mill to avoid environmental problems due to equipment break-down or emergencies. This includes stand-by equipment as well as diversion lagoons where water can be stored for later treatment.

Comment: Back-up or safety measures should be incorporated in any wastewater management scheme aiming at preventing environmental problems arising from normal operation as well as emergencies.

g) **Water recycling and consumption.** All four Asian mills practiced water reuse of up to 90% to 95%.

Water discharged was indicated in the order of 95,000 m^3/day for a plant capacity of 9,000,000 tonnes of steel per year.

The Canadian mill indicated an effluent flow of approximately 41,000 m^3/day for production of 1,500,000 tonnes (35% - 50% scrap) of steel per year.

h) **Summary of water pollution control technology at the Japanese mill.** A summary of water pollution control technology applicable to the pollutants presently regulated at the Japanese mill is shown in Table 1.

TABLE 1

Summary of Water Pollution Control Technology in Japanese Steel Industry

Pollutant	Major Sources	Control Techniques
COD (Chemical Oxygen Demand)	Coke oven gas liquor	Biological treatment - coagulating sedimentation (further treatment)
	Rolling process effluent	Use of low sulfur materials and fuels
	Cold rolling pickling effluent	Coagulating sedimentation - neutralization
Oil	Hot rolling process effluent	Neuturalization, Flotation Separation
	Cold rolling process effluent	Coagulation, Flotation, Separation
Pickle Liquor	Cold rolling process effluent	Sulfuric acid recovery Hydrochloric acid regeneration Deep Well
Primary Solids	Industrial wastewater of main plant	Clarifier Air flotation unit Sand filters
Secondary Treatment of Oxygen Consuming Wastes		Aerator Aerated lagoon
Tertiary		Flocculating tank Flocculating and clarifying unit
Sludge		Thickener Vacuum filter

(Reference: "Current Status and Problems of Environmental Control in the Japanese Steel Industry" 1980, Tokyo, Committee on Environmental Affairs, IISI)

All four Asian mills indicated that wastewaters were treated at separate facilities within the plant and the number of such facilities ranged up to 18 in a single plant.

None of the four Asian mills had provisions for emergency collection of effluent in case of a break-down of water treatment facilities.

The capital cost of water pollution control at a new greenfield plant is estimated to be in the order of 2% to 4% of the total capital cost.

7.3 Summary of Major Findings

a) The technology to treat wastewaters generated at an integrated steel plant is available and can produce a final effluent of high quality.

b) Analysis carried out at the Canadian mill shows that persistent organic chemicals of concern are either not detectable or are present at very low levels.

c) The final effluent from the Canadian mill does not appear to have any significant effect on the receiving waters, including the fresh water ecosystems, fish viability or reproduction.

d) Water re-use and recycle can be practiced to a level as high as 95%, resulting in a lower volume of effluent and in a decreased load of pollutants to the environment.

e) Back-up or safety measures are practicable and can be incorporated into the wastewater management scheme.

f) The capital cost of wastewater treatment at the most advanced mills visited is in the order of 2% to 4% of the total capital cost of a new greenfield mill.

g) Storm water runoff from large areas used for stock piling raw materials can be collected and treated before re-use or discharge into receiving waters.

7.4 Supplementary Concerns related to Special Wastes

Recently there has been concern in British Columbia over chlorinated dibenzodioxins and dibenzofurans in the marine environment. Analysis of the final effluent from the Ontario plant specifically for these substances showed them to be absent.

Other materials of special concern in water have been examined by trace analysis techniques in Ontario:

- heavy metals e.g. Cr^{6+}, Pb, Ni, Zn
- volatile organics (benzene), and halogenated volatile organics (tetrachloroethylene).
- polycyclic aromatic hydrocarbons (PAH)

All these substances have been found to be absent or at low levels in the effluent. Extensive data sets are available.

8.0 POTENTIAL IMPACT ON AIR QUALITY

8.1 Pollutants

Air quality impacts from integrated iron and steel operations are currently principally assessed by measuring SO_2, NO_x (NO_2 and NO), and particulate emissions. Dust originating from raw material stockpiles (coal and iron ore), and from roadways is also monitored.

The monitoring of volatile organic compounds (VOC) including methane and more reactive hydrocarbons (RHC) is being introduced. Ambient levels of RHC are currently recorded in the vicinity of the Ontario plant.

Other parameters of air quality in the vicinity of facilities are fluoride ion, ozone and total reduced sulphur (sulphur and sulphide). The latter compounds are important in contributing to potential odor problems.

8.2 Control Measures

As has been described in the section on the processes of an integrated iron and steel plant, there are many specific sites where NO_x, SO_x and particulate can be encountered. Control measures are developed taking into account the gas temperature, composition of the particulate (for example presence of alkali metals in the sinter flue gas, or graphite dust from torpedo cars) and composition and oxidation state of the flue gases (for example, sulphur as SO_2 or H_2S).

Particulate removal employed from 50 to 111 separate dust collecting facilities in each plant - both primary collection on the direct exhaust and secondary collection at transfer points. Fugitive emissions from the charging and pouring or tapping operations were current concerns in the industry. Hooding and complete enclosure were introduced.

Total SO_x (SO_2 and SO_3) production was of particular concern at mills with sinter plants, and in the flue gases from the coke ovens, blast furnaces and basic oxygen furnaces. Patented (commercial) desulphurization processes recovering sulphur as ammonium sulphate or sulphuric acid are highly developed in the Japanese industry both for removal of H_2S (coke ovens) and SO_2 (sinter plants). Sourcing low-sulphur iron ore and/or coking coal, however, remains highly effective. Feed coal sulphur values as low as 0.55% (Taiwan) were noted.

Control of NO_x, a particular pre-occupation in Asia because of the high density of cars and trucks was approached via a range of combustion improvements. The so-called thermal NO_x countermeasures include re-circulation of exhaust gases, low-NO_x burners and low-oxygen-control combustion. Technologies for NO_x removal are being developed. Some 40% to 60% of the NO_x (as NO and NO_2) arises from sintering plants. Difficulties are encountered with the accompanying particulate load (including alkali metal content) in the flue gas. Promising technologies are based on selective catalytic reduction methods employing ammonia and iron ore or iron silica alumina catalysts.

8.3 Effectiveness

Not unexpectedly, there was some sensitivity to publicly releasing data from particular mills on effectiveness of pollution control (both on regulatory and proprietary grounds) even when results are impressive. Table 2 shows the range of values encountered for the principal air pollutants, with a comparison to existing British Columbia regulations for mining, smelting and related industries. Some values have been obtained for both ambient and emission (point source) levels. It is noteworthy that in three of the five mills, continuous (computer) recording was in operation, either for in-plant use or by direct telemetering to local or provincial government offices. Two Asian mills had direct display-terminal readout, with hourly printout of principal pollutants. Direct TV monitoring of unit operations (and stack plumes) was observed. A focus of the Ontario monitoring was the establishment of up and downwind stations so that effects on the air shed as a function of prevailing wind (based on meteorological data) were readily determined.

In the case of the C.S.C. mill, air pollutant measuring results based on a contracted assessment were made available, together with the present Japanese, Taiwanese and German standards. These are shown in Appendix III.

TABLE 2

Air Quality Values - Comparison with B.C. Standards

	$NO_2(NO_x)$		$SO_2(SO_x)$		Particulate/NM^3	
	Point ppm	Ambient[a] ppb	Point ppm	Ambient[a] ppb	Point mg	Ambient[a] ug
Mill 1	N/A	19	194-338	25	78-235	130
Mill 2 (57)[b]	N/A	N/A	N/A	11-26	N/A	32
Mill 3 (34)[b]	170	40	160	20	50	240
Mill 4	60	N/A	<100	N/A	N/A	N/A
Mill 5 (13)[b]	N/A	2[e] 30[d]	N/A	5-6	N/A	40[c]
B.C.	300	N/A	250	10	46	150[d] 60[e]

N/A either not available, or meets standards for range of standard values.

[a] Local community/air shed; or boundary value

[b] Refers to the number of monitoring stations involved

[c] Annual geometric mean

[d] 24 hour average

[e] Annual average

A state-of-the-art steel facility producing 3,000,000 tonnes of steel per year would be able to meet rigorous discharge and ambient air quality standards in British Columbia.

Without desulphurization, SO_2 emissions total about 2,900 to 3,500 tonnes of SO_2 per million tonnes of steel produced. For a 3,000,000 tonne per year steel facility, this amounts to 8,700 to 10,500 tonnes of SO_2 annually, approximately equivalent to the total sulphur emissions from three kraft pulp mills.

A new greenfield plant (based on the Japanese example) is able to suppress SO_x significantly over the value cited above. For example, for specific (point) sources, SO_2 suppression at a

sinter plant was from 200 ppm to 1 ppm, and at the coke oven gas desulphurization plant H_2S suppression was from 4,000 ppm to less than 100 ppm. These values are considerably lower than the anticipated or probable British Columbia standard. NO_x suppression in a new sinter plant facility was rated at 300 ppm to less than 60 ppm.

Best available control technology for a new world-class plant would include desulphurization, denitrification, and rigorous particulate control such as at the NKK Keihin plant and computerized environmental monitoring as at the Pohang Iron and Steel Company Kwangyang plant.

Notwithstanding these point-source emission values, the overall emission of the facility, - the so called "bubble" value - is projected as the new standard in the Asian mills. With new technology, the overall SO_x value for a 3,000,000 tonne a year greenfield plant can approach emissions from a coal-fired power facility in current operation in Western Canada.

8.4 Monitoring and Ecological Effects

It is important to note that with the higher population densities of the Asian urban areas, there is increasing attention being paid to the total particulate, SO_x, NO_x and hydrocarbon loading. For example, in Japan local area standards for SO_x emission are established and local city or prefecture agreements are negotiated. In Taiwan, the concept of the boundary value (just outside a facility) is in force for operations with more than three point sources (stacks) for a specific pollutant. In Taiwan, the authorities intend to move to the integrated output of a facility as the standard, as a means of monitoring total impact on surrounding air quality.

In Ontario, the combined effects of the steel operation and a nearby refinery and coal-fired power plant were being considered. Significantly, the power plant had the highest SO_x potential.

Improving the performance of mobile sources (autos, trucks and scooters) is the principal pre-occupation of the Asian urban authorities, and the sustainability of new industry in British Columbia may well be viewed in the context of overall progress in air emissions from all sources.

9.0 GENERAL CONSIDERATIONS TOWARDS AN ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT

9.1 Introduction

The proposal to site a fully integrated steel mill in British Columbia presents not only a challenge to establish the most exacting current and future environmental standards, but also an opportunity to demonstrate the principles inherent in the dual consideration of the economy and the environment. Since a greenfield steel mill will represent a departure from the traditional economic base of the province, the contrasts and comparison with the environmental effects of current activity are especially important. Impacts on the local community, safeguarding of the natural environment in the immediate area, and meeting current provincial, national and international environmental objectives will all be important.

Consequently, every aspect of the siting, planning and execution of such a facility would be subject to exacting scrutiny. A number of considerations would likely bear on the success of the planning phases, some broad in scope, others relatively focussed and "people" oriented.

Some of these issues are as follows:

9.2 Conservation of Energy and Materials

The Survey Team has seen a number of examples illustrating the possibilities for conservation of energy and materials.

a) Repeated water reuse (after interim purification) - the so-called "cascade system" - can result in only 3% to 5% daily make-up in a modern plant.

b) Recycling of iron containing scale and dusts into the sinter and blast furnace operations reduces solid waste production. Even use of wastes containing zinc and

lead is made possible by methods (reduction) that remove these metals and recover their economic value. Significant scrap is recycled (up to 20% of the charge) in the basic oxygen furnace. Scrap use is not restricted to electric arc furnaces (mini-mills).

c) Residual solid waste is represented in large measure by blast furnace slag . Especially in Japan, use of this material for construction (cement) and road building approaches 100%. Careful analysis (for heavy metals), monitoring of leachate and new materials technology makes these applications possible.

d) In some cases pollutants themselves (NH_3 from the coking plant) can be used to capture other pollutants (SO_2). In this case the product ammonium sulphate actually can be marketed.

e) Energy efficiency is pursued by overall plant design, including an integrated (computerized) central control room. Power generation can be achieved both from the heat content of the flue gases and from the carbon monoxide and hydrogen content of the gas (from the coke ovens and blast furnace).

9.3 The Greenhouse Effect

Technically, reduction of iron ore (Fe_20_3) to iron (Fe) requires expenditure of a reducing agent, the carbon of coal, and application of heat. The thermal and CO_2/CO consequences of iron production are inescapable. Siting an integrated mill in British Columbia would not increase the burden of greenhouse gases - provided we consider the earth as a closed system and overall world capacity does not increase significantly. In British Columbia, any additional fuels that are required can be largely supplied by natural gas, decreasing the particulate and SO_2 encountered with heavier fuels. As well, the extensive use of coke oven and blast furnace gas for power generation in a new plant would minimize the requirement for extra fuels. Interestingly, decommissioning existing integrated mills in the high-sulphur Eastern US would actually be of benefit on a world scale.

Clearly from the British Columbia standpoint there could be local impacts of such large scale energy consumption. Particulate would be a concern. However, in Ontario annual dustfall levels near the steel plants now approach normal background levels.

Cooling of water prior to addition to the receiving waters would be a high priority to lessen the effects on marine (or fresh water) ecology.

9.4 Social Aspects

As part of the challenge, a new plant would need to pay careful attention to both the working and the receiving environments. Worker safety and occupational hygiene would be easily introduced in a greenfield plant; noise abatement and workplace air quality considerations would accompany outside emission standards of the highest order.

With worker awareness, a high level of training in both environmental considerations and in the maintenance (and efficiency) of environmental equipment would be easily attained. Sustained breakdown-free operation would be the goal.

9.5 Aesthetic Aspects

From our Asian experience, all of the technical commitments and the placing of the environment as the top priority can be best advertised by a highly visible program of landscaping and greenery. In Korea, extensive tree and flower plantings (red roses) were observed on the site and in the surrounding areas where the workers lived. The Japanese and Taiwanese mills also had extensive on-site tree-planting programs. The benefits of the "greening" of industrial locations are many - the aesthetic impacts on local areas are minimized, the vegetation zones reveal the inherent lack of impact on the environment that can be achieved, and the barrier of the trees reduces the drift of any particulate on to adjoining areas.

9.6 Public Participation

As a part of a new venture, a new standard of public process should be established, with agreements reached at local, provincial and federal levels. Baseline studies (and ongoing monitoring) are essential. Water quality (temperature), populations of flora and fauna and atmospheric levels (SO_2, NO_x, O_3, F_- and hydrocarbons) would be established beforehand. Progressive planning, such as prior consideration of any transport of hazardous goods and emergency planning for natural disasters should be undertaken.

Local community reaction and input via public meetings would be particularly important in such an approach. Community infrastructure, goals present and future, land use strategies of the local area and the bioregion would be considered. (See the previously mentioned process undertaken in the Lake Erie siting, as described in Appendix I.) Two concerns stand out in this regard - solid waste disposal, and fresh water supply (present and future use).

Finally the glue to such an overall planning and implementation program would be an appeal to industry (and technology) sectors in British Columbia to participate in leading-edge developments in pollution control technology.

10.0 CONCLUSIONS

Conclusion #1

Based on the observations and information obtained both in Asia and from Candian sources, available air and water emission control technology and modern solid waste management practices justify proceeding with pre-feasibility studies of the establishment of an integrated iron and steel production facility in British Columbia.

Conclusion #2

In the past 15 years, technology and equipment has become available that can maintain much-improved environmental standards in the iron and steel industry. The percentage of capital costs involved for environmental control now may range from 12% to 20% of the initial investment.

Conclusion #3

The ultimate environmental feasibility of an integrated iron and steel plant will depend on establishing rigorous criteria and standards for the maintenance of air and water quality, for control of the analysis and sampling of the environment, and for marine and land monitoring including initial base line studies.

Conclusion #4

From observations in other jurisdictions, site selection of a greenfield plant involves assessment of the assimilative capacity of the area, based on the combined and cumulative effects of population and industrial activity. The capacity includes the long term sustainable viability of marine (or freshwater) and terrestrial ecosystems in the region.

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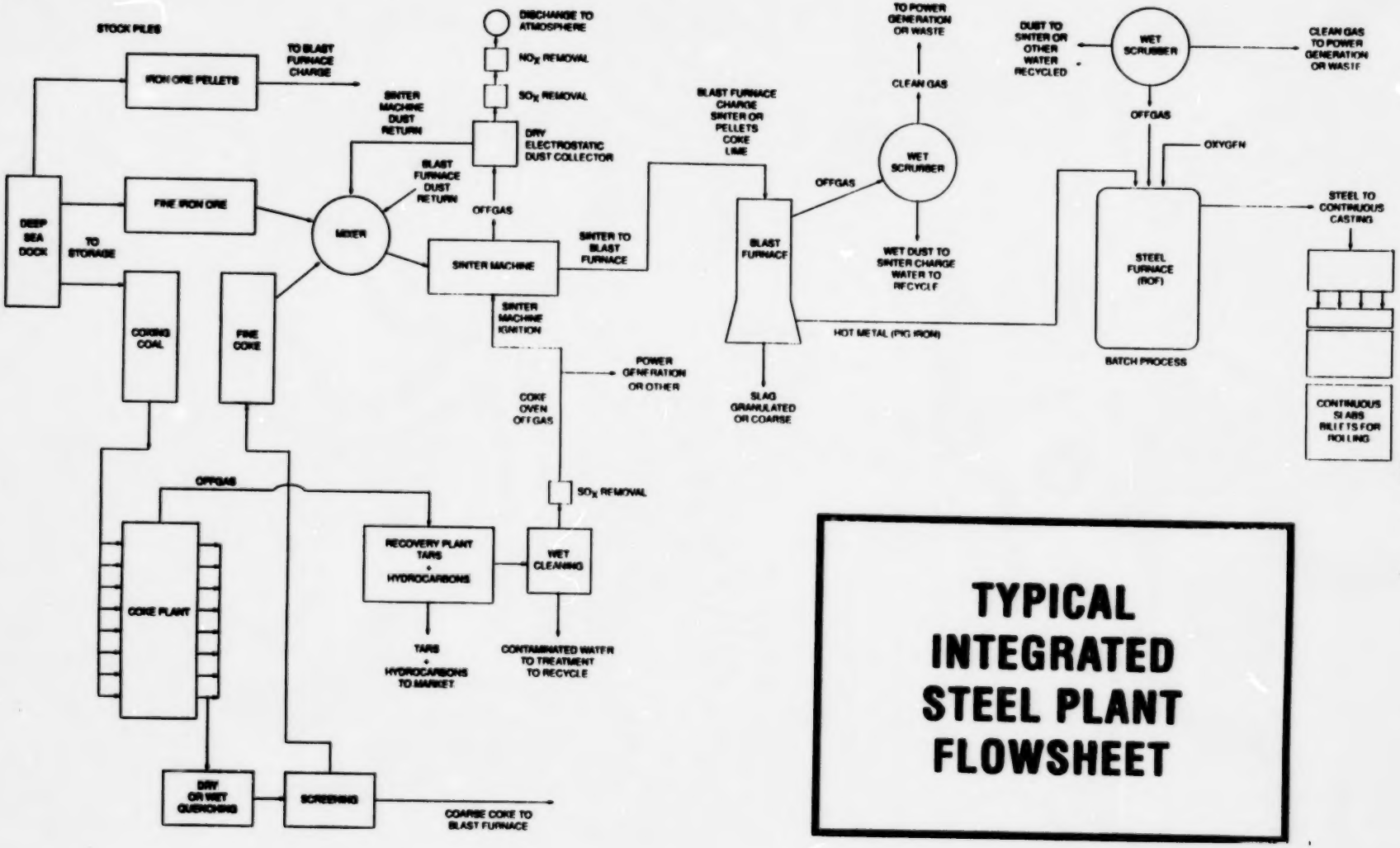

TYPICAL INTEGRATED STEEL PLANT FLOWSHEET

APPENDIX I

ENVIRONMENTAL CONTROL

AT

LAKE ERIE WORKS

STELCO STEEL

A DIVISION OF STELCO INC.

LAKE ERIE WORKS

In 1968, Stelco Inc. recognized that it required a significant increase in its productive capacity by 1985 to satisfy the demands of Canada's growing population. Since property at the existing basic steel facility in Hamilton is limited, the Company initiated a study to find a new site for a separate steel plant. This study resulted in the purchase of 2,640 ha (6,600 acres) of land on Lake Erie near the small town of Nanticoke as the site of the future new steel facility. The site is on Lake Erie about 64 km (40 miles) south of Hamilton and 113 km (70 miles) southwest of Niagara Falls.

The site was chosen for the following reasons:

1. Access to water transport is available for our major raw materials which are coal from the United States across Lake Erie, and ore from sources in Michigan, Northern Ontario and Labrador.

2. The site is close to our supply of limestone at Beachville.

3. It is close to a labour supply in Hamilton and surrounding areas.

4. It is close to a major market area in the Golden Horseshoe.

5. A large tract of sparsely populated land existed.

It was recognized at the outset that the planning for this new plant would have to include the most advanced technology to control pollution, some of that technology unknown at the time the land was purchased. In addition, a concept had to be devised which would supersede merely adhering to environment standards, and produce a plant pleasing to the community.

As part of this concept, sufficient property was purchased so that a portion of it could be set aside for an Industrial Park. This provides a buffer between the heavy industrial steel plant and the community, and permits environmental control of secondary industry, so that high standards of environmental planning will apply to those as well.

Scope

The first stage of the project is designed to produce about 1.2 million tonnes of raw steel. It is expected this plant will eventually grow to be at least as large as the existing Hilton Works plant in Hamilton before the year 2000. The main facilities of the first phase are:

1. A raw materials receiving dock.
2. A raw materials storage area.
3. A Blast Furnace.
4. A Basic Oxygen Steelmaking Shop with continuous Slab Casting.
5. Service facilities such as a Steam Generation Plant, Machine Shop, Stores, offices, etc.
6. A coke-making facility.
7. A semi-continuous Hot Strip Mill.
8. Finishing facilities for the Hot Strip product.

Items 1 to 5 began operation during the first six months of 1980. Item 3 is scheduled to begin operation in 1981, and items 7 and 8 are to start up in 1983. The total cost of these facilities will be well over one billion dollars.

Environmental Assessment & Preplanning

To fit a facility of this magnitude into a rural environment requires a special environmental approach. The existing landscape is undulating but relatively flat farm land which consists of Haldimand clay.

Consideration of our project had to be co-ordinated with the other plans for future development in this area. Ontario Hydro had purchased land and started construction of a large coal-fired power plant about 1.61 km (1 mile) to the east of us before our plans were announced. This Hydro development is capable of producing in excess of 4,000 megawatts of power. Shortly after the announcement of our property purchase, Texaco purchased land immediately north of Hydro and has constructed a 95,000 barrel-per-day refinery. Following studies by Provincial Government agencies and a great deal of activity by private developers, the Province eventually acquired the site for a ne town immediately northwest of the town of Jarvis. A second town site was also acquired east of our plant, closer to Cayuga. The town site near Jarvis, normally called the Townsend site, received its first houses in 1980.

Returning to our plans, the first step in environmental planning must be the assessment of existing baseline conditions in the ecosystem. To this end, a co-operative study of the water regime was initiated in 1969 with the Ontario Ministry of the Environment, the Ministry of Natural Resources, Ontario Hydro, Stelco and Texaco sharing the cost.

The separate studies covered the following areas:

1. water temperature
2. water quality & chemistry
3. water movement
4. weed bed location and extent
5. phytoplankton - zooplankton
6. the structure of the Long Point fishery
7. bottom fauna
8. ice observations

The water temperature studies were a prime interest to the Power Commission, of course, because of the magnitude of their cooling water usage. The fishery study had a special significance to the whole area because of the Region's history as a commercial and sport fishery. In one year, this particular study involved the capture of 15,000 fish of 28 different species.

These studies have continued and will do so for at least two years to measure the impact of the new facilities on the area.

Air quality studies have been carried on concurrently. Started originally by the Ministry of the Environment and Ontario Hydro, they include a network of test stations surrounding the industrial area. These include sampling devices for many pollutants within a radius of 19 km (12 miles) of the Site. These test for suspended particulates, sulfur dioxide, fluorides, iron, oxidants, sulfurization, etc. control plots of white ash, which is sensitive to sulfur dioxide, have been established at distances from 3 to 80 km (2 to 50 miles) from the Site. Plantings of tree seedlings of birch, pine and ash have been included as well. In addition, indicator plots of annual plants such as the sensitive gladioli and pinto bean have been established for control purposes.

In 1978, this program was expanded and a joint monitoring network sponsored by Ontario Hydro, Stelco, Texaco, Ontario Ministry of the Environment and Environment Canada was formed under an association called the Nanticoke Environmental Management Programme (NEMP).

Air quality observations will continue into the future to record the effect of industrialization and other development.

However, environmental appraisal does not involve only air and water quality. In 1970, the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs completed the "Haldimand-Norfolk Environmental Appraisal" which was authorized by Victor Chanasyk, and studied such areas as:

a) historical background
b) geology
c) atmospheric inventory
d) historical ecology
e) forest land use
f) agricultural land use
g) fisheries
h) wildlife resources
i) soil suitability for urban & industrial uses.

Other reports dealt with the demographic impact, regional financial aspects, a land use plan for Haldimand-Norfolk, the Lake Erie shoreline, inland fisheries, historical and archaeological sites, transportation, erosion, housing, a strategy for southwestern Ontario development, an appraisal of social problems and needs in the Haldimand-Norfolk area, etc.

In fact, we once catalogued some 44 studies regarding the area and more have been done since then.

Environmental Design & Planning

It was recognized at the early stages that environmental planning must go beyond merely meeting environmental standards and an effort has been made to blend this development into the rural landscape. The objective has been to preserve the aesthetics of the existing landscape, and especially the vistas from roads and adjacent areas.

We wish to avoid the stark effect of man-made structures which have not been tied to the landscape. What we consider ideal is to blend in the structures using trees, low bushes and other means.

The concept that has been developed and implemented involves earth mounding and tree planting. We have installed earth berms and trees which not only buffer the view of the plant from nearby roads but also deflect wind away from our plant in that immediate area and have some desirable effect with regard to noise as well.

An extensive greenbelt area with mounds and trees have been established on the east side of our property. A new scenic road has been built through this area to replace an existing road which went through the plant and this is flanked by earth mounds and water ponds. Similarly, earth mounding and tree planting has been established along the south side of the first stage. Thousands of trees have been planted and a tree nursery has been established for future use.

Within the Industrial Park area, a significant portion of the property is set aside for greenbelt or wildlife preserves. The habitat of a small colony of Hungarian partridge and a more extensive habitat for blue heron are to be preserved.

With regard to the facilities themselves, the dock is a dominant feature since it is 1,191 metres (3,908 feet) long to reach deep water. This involved environmental studies of its own and the design was changed to include a bridged area near shore to maintain the flow of currents, fish movement, the travel of littoral drift (sand, etc.) and to prevent undesirable changes to the shoreline.

In addition, where the conveyor from the dock reaches shore, it is depressed and moundings and trees provided on each side so that it will be hidden from the surrounding areas.

Within the steel plant, water is recirculated to the greatest degree practical. In fact, we do not have our own water intake but are supplied from a pumphouse installed by the Ministry of the Environment using Hydro intakes. The Ministry wished to control the number of intakes and outlets.

From all of the water recirculation systems, a small stream has to be bled off to prevent a tea kettle effect which would result in deposits of dissolved solids in piping. This bleedoff stream is treated in separate facilities to remove chemicals, oil and solid contaminants. The discharge from these treatment facilities goes to a backup safety lagoon before discharge to the Lake.

Progress

Environmental approval for the dock and the Site generally was received in August 1974, subject to certain conditions which had to be fulfilled.

Subsequently, stringent construction guidelines were established for dock construction. This involved extensive study of the effect of fish and blasting of rock in the dock area and water quality and other biological tests during the various stages of dock construction. In addition, construction had to be suspended at certain times of the year so as not to interfere with fish pawning.

Generally speaking, the construction of the dock proceeded without incident and the blasting caused little problem due to close control of the size of the charge, etc.

Tree-planting for the greenbelting began in the fall of 1973 and the earth mounding continued during the construction seasons of 1974 and 1975. Production started in June 1980.

Summary

In summary, our objectives have been to comprehensively plan, at the outset of this project, to integrate the plant into the landscape and to build a plant which is environmentally acceptable. We believe that we have been successful.

APPENDIX II

Appendix II A

AMBIENT AIR QUALITY
B.C. 1979 Pollution Control Objectives

A. DISCHARGES TO AIR

TABLE 1. Ambient Air Control Objectives

Parameter(1)	Unit	Range		Canada	Korea	Japan	Ontario	Taiwan
1. Sulphur Dioxide								
Annual Arithmetic Mean	$\mu g/m^3 (ppm_v)$	25(0.01)	75(0.03)	(0.02)	(<0,3)	(.04)	(0.02)	(<0.03)
24 hour conc.	$\mu g/m^3 (ppm_v)$	160(0.06)	260(0.10)	(0.10)	Boundary		(0.10)	Boundary
3 hour conc.	$\mu g/m^3 (ppm_v)$	375(0.14)	665(0.25)			(.1)		
1 hour conc.	$\mu g/m^3 (ppm_v)$	450(0.17)	900(0.34)				(0.25)	
2. Asbestos(chrysotile)	Fibres/cm^3(2)	less than .04						
3. Dustfall	mg(dm^2-d)(tons/m^2/mo)	1.7(15)	2.9(25)				0.23g/m^3 /day	
4. Suspended Particulate								
Annual geometric mean	$\mu g/m^3$	60	70	60 annual	<500	100 daily	60 annual	<500mg/Nm^3
24 hour conc.	$\mu g/m^3$	150	200	120 day	Boundary	120 hourly	120 daily	Boundary
5. Radon Daughter Concentration (5)	WL	less than 0.02						

NOTES APPLICABLE TO TABLE 1

(1) Sampling will be in a form and manner over periods of time specific by the Director of Pollution Control.
(2) An asbestor fibre greater than 5 µg in length with a length to breadth ratio of 3:1 or greater.
(3) Total gaseous and particulate.
(4) Measured as total gaseous and particulate fluoride.
(5) To apply to operations where the objective is not the mining of radioactive ores.

NO_x	(0.2)ppm hourly		(0.04)	(0.20)hour	(<0.25)		
CO			(10)ppm daily	(0.10 day	Boundary		
Ozone	(0.08)ppm hourly		(20)ppm hourly	(0.08) hourly			

Appendix II B

Gaseous and Particulate Emissions

Material to be provided in forthcoming addendum.

Appendix II C

Discharge of Final Effluents to Marine and Fresh Waters

Material to be provided in forthcoming addendum.

APPENDIX III

A. Comparison of CSC Water effluentmeasuring result and Taiwan, R.O.C., Japan, Germany Standard

Pollutant item	PH Value	SS MLSS	COD	OIL	Phenol	NH_4^+	CN^-	Cr^{+6}	Visibility
measuring Results	7.60	27.8mg/l	98mg/l	1.0mg/l	0.25mg/l	173mg/l	0.54mg/l	0.04mg/l	29.4CM
Present R.O.C. Standard	5-9	<200mg/l	<300mg/l	<10mg/l	<5mg/l	—	<1mg/l	<0.5mg/l	>15CM
Present Japan Standard	—	<200mg/l	<120mg/l	<5mg/l	<5mg/l	—	—	<2mg/l	—
Present Germany Standard	—	<0.5mg/l	<300mg/l Coal(Wet)	—	<1mg/l Coal(Wet)	—	0.5mg/l Coal(Wet)	—	—

Reference: 1. Germany standard related to coke plant effl. of 590l/t coke supply by can-still. Germany
2. Japan standard supply by sumitomo metals. Japan.

B. Comparison of CSC Air Pollutant Results and Taiwan R.O.C. Japan, Germany Standard

Pollutant item	Number of Measuring locations	Measuring results	Present R.O.C. standard	Present Japan standard	Present Germany standard
SOx	34	5–315 ppm Total emission load 627 Nm^3/h	750 ppm	K value ordinary special 3.5 1.75 Total emission load 932 Nm^3/h	243 ppm
NOx	30	16–300 ppm	1000 ppm	60–480 ppm	175 ppm
Particulate	85	1–100 mg/Nm^3	700 mg/Nm^3	50–100 mg/Nm^3	150 mg/Nm^3
HCl	5	5–42 ppm	80 ppm	469 ppm	18.4 ppm

Reference: Japan standard supply by sumitomo metals. Japan Germany standard supply by Can-still industry, Germany